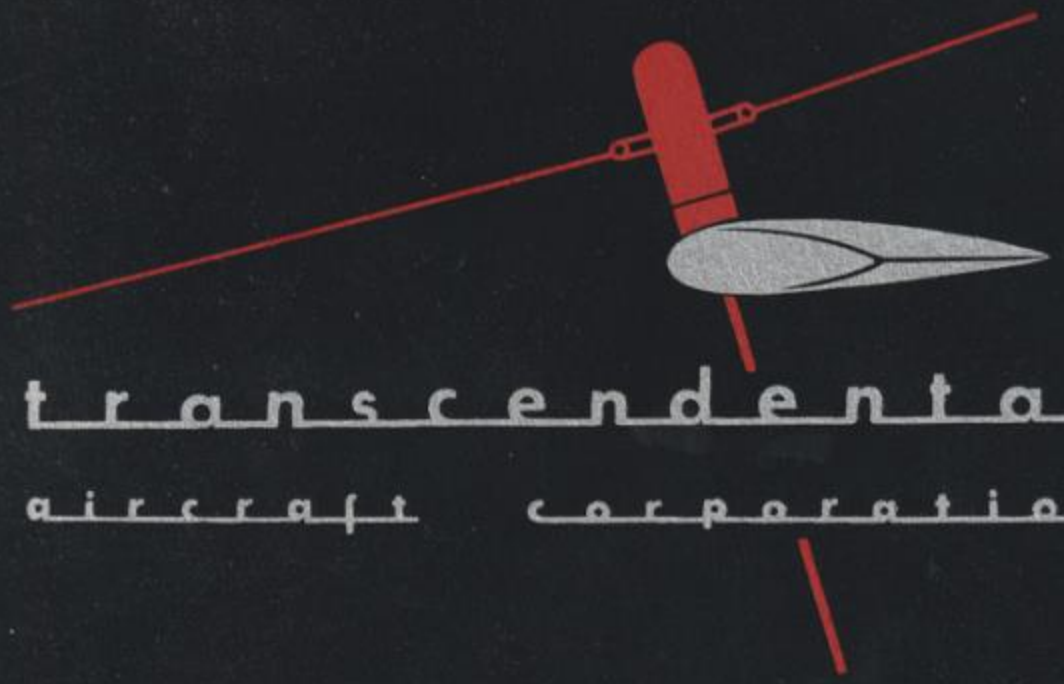
QUARTERLY PROGRESS REPORT
(15 Sept. 56 - 15 Dec. 56)
CONTRACT NO. AF 33(616)-3647
TASK NO. 449 L
PROJECT NO. R-56-662-TC



transcendental

aircraft corporation

15 January 1957

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CONTRACT NO. AF 33(616)-3647
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Submitted to:

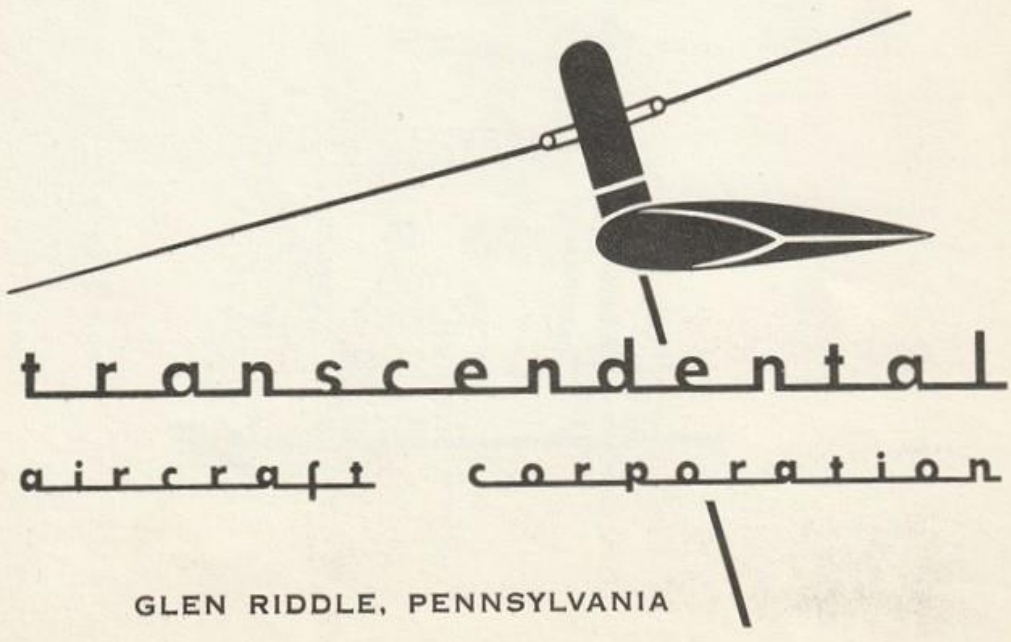
COMMANDER, DETACHMENT #1

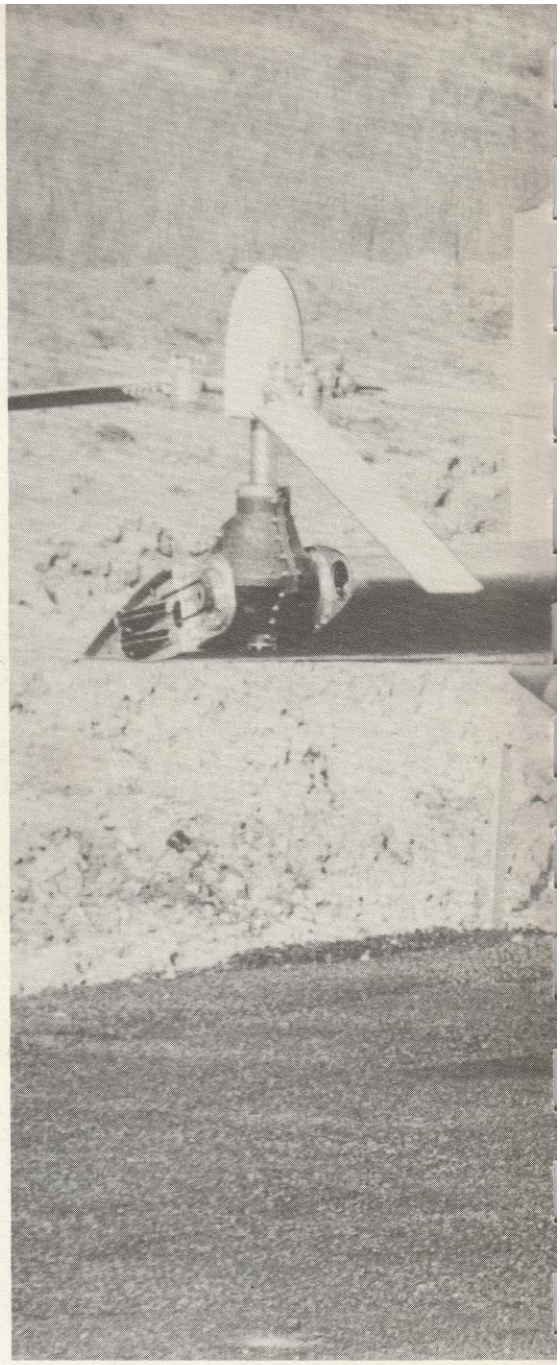
AIR RESEARCH & DEVELOPMENT COMMAND

WRIGHT - PATTERSON AIR FORCE BASE, OHIO

Attn: RDZSBR

By





FOREWORD

This progress report covers the period from 15 September 1956 through 15 December 1956 and includes a general review of the progress made on this contract from 15 March 1956 through 15 December 1956.

Model - 2 CONVERTIPLANE

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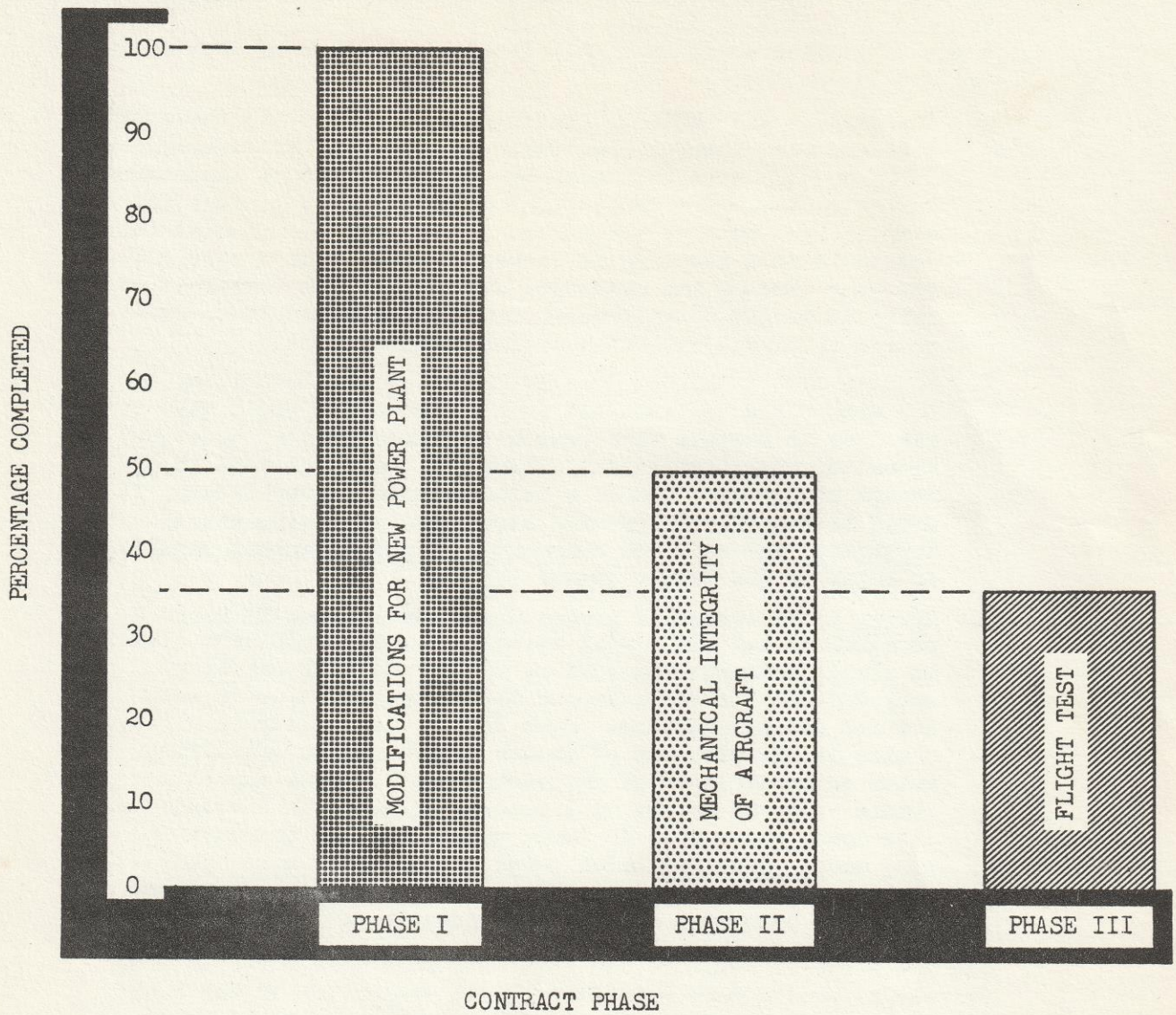
SUMMARY OF PROGRESS



SCOPE OF PHASE I MODIFICATIONS

Phase I of Contract No. AF 33(616)-3647 consists of modifications to the Transcendental Model 1-G required to accommodate a Lycoming O-435-23 engine as a replacement for the original Lycoming GO-290-A engine. As a result of studies conducted by the contractor which indicated that it would be more economical in both time and money to build a new aircraft, it was decided to fabricate the Model 2 rather than modifying and rebuilding the Model 1-G. This decision was predicated upon the following technical conclusions.

1. Replacing the Lycoming GO-290-A engine with the O-435-23 would produce an undesirable rearward shift of the aircraft's center of gravity, thereby requiring complex fuselage modifications for accommodation of the new engine.
2. A new wing appeared to be highly desirable because of the following considerations:
   a. The wing on the Model 1-G had a poor weight-to-stiffness ratio, and work accomplished under Contract No. Af 33(616)-2127 had indicated that stiffness is of paramount importance in the control of vibration which can cause mechanical instabilities, both in flight and on the ground. Studies indicated that a new wing of increased area, with a continuous spar through the fuselage, and with a much improved ratio of weight-to-stiffness, could be designed at no increase in weight over that of the original wing.
   b. Studies also indicated that by proper design technique, the new wing could be layed out in a manner which would make it possible to compute with reasonable accuracy its structural vibration characteristics. Thus, for the first time in the design and fabrication of a tilting rotor convertiplane, it would be possible to predict structural vibration characteristics, and to check computations against actual results by means of pre-flight shaker tests.
   c. Again, by selection of proper design technique, it would be possible to lay out a wing structure which would lend itself to simple span-wise expansion, while retaining excellent weight-to-stiffness ratio and ease of computation of vibration characteristics. Such design flexibility is highly desirable for purposes of future investigation of tilting rotor convertiplanes of increased size, because any increase in gross weight will probably require an increase in disc area, which will in turn, necessitate an increase in wing span. A design which permits increasing wing span without changing tooling will permit future investigations of growth potential of this configuration at minimum cost.
3. The new aircraft could be designed with much less parasite drag thereby affording more realistic flight evaluation of the basic advantage of the convertiplane (higher speed potential) over conventional rotorcraft. Moreover, the higher resulting speed potential offered the possibility of revealing significant technical data that might not be apparent at the lower speeds attainable with a "dirtier" airframe.

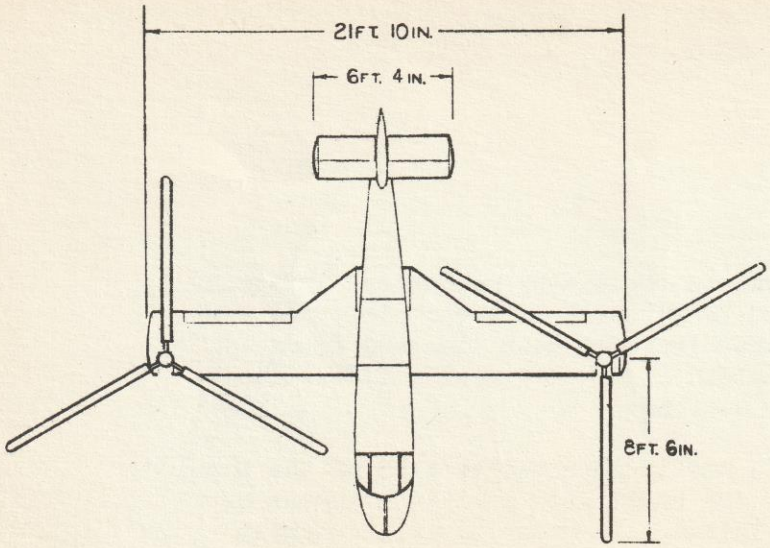
4. The contract requirements concerning mechanical integrity of the aircraft could be met with more certainty and with a more economical expenditure of both time and funds by complete redesign instead of by piecemeal modification to a basically inferior airframe.

Although the Model 2 is a vastly improved version of the Model 1-G, the former was designed and built with a minimum amount of basic modification from the latter. In order to avoid unknown technological areas, the basic design parameters of the Model 1-G were maintained in the Model 2, as is evident in the tabulation of comparative general specs on page 7. For example, in order to keep the disc loading of the Model 2 equal to that of the Model 1, the rotor diameter was increased one foot. Similarly, to avoid adverse Mach effects, solidity was increased by lengthening the blade chord by one inch. The tip speed of the larger rotor was made equal to that of the Model 1-G by changing slightly the gear ratio in the new center transmission which required redesign for other reasons that are enumerated below.

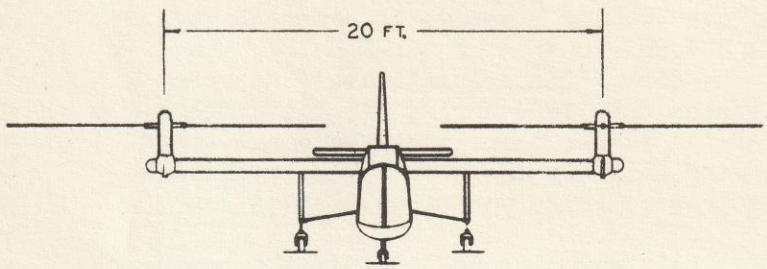
In the original studies, it had been planned to limit the power taken from the Lycoming O-435-23 engine to approximately 175 hp. This limitation would yield an expected life of 6 hours on the old center transmission. However, with the increased instrumentation system weight and the more comprehensive flight test program, it became apparent that it was highly desirable to utilize the full power output of the O-435-23 engine and extend the gear life to 2000 hours. Under this condition, the capacity of the original center transmission was marginal. The increased number of flight hours involved in the expanded flight test program dictated the decision to design, fabricate and install a new center transmission of increased capacity.

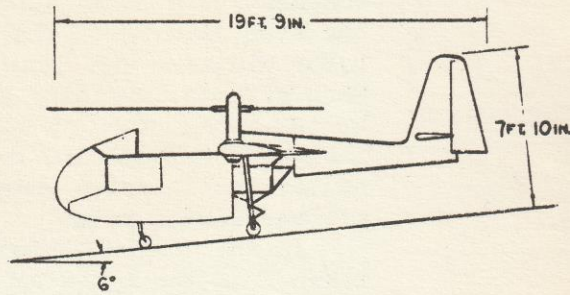
While keeping the basic design parameters of the Model 2 equivalent to those of the Model 1-G, the following significant improvements were made:

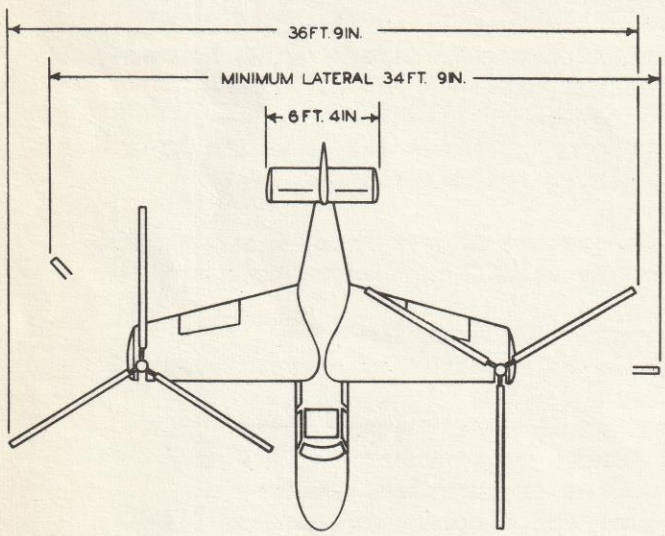
1. Ejector cooling was incorporated with a saving of 10% of the engine power output which would be required by conventional fan cooling.
2. The new control system (required to meet the mechanical integrity and reduced control forces requirements of the contract) incorporates unique design features and integrates the controls for the helicopter and airplane regimes of flight.
3. The new center transmission (required for previously detailed reasons) has been designed to absorb up to 1000 horsepower at 6000 rpm, providing potential for future shaft turbine conversion at minimum cost.



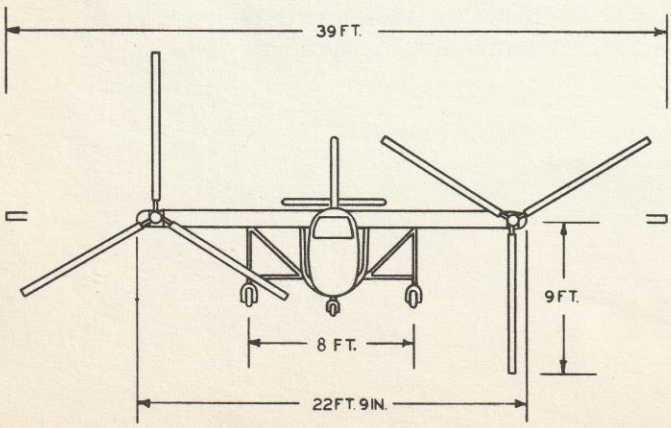
Model 1-G CONVERTIPLANE

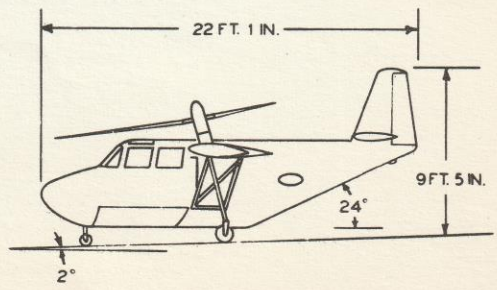






Model-2 CONVERTIPLANE

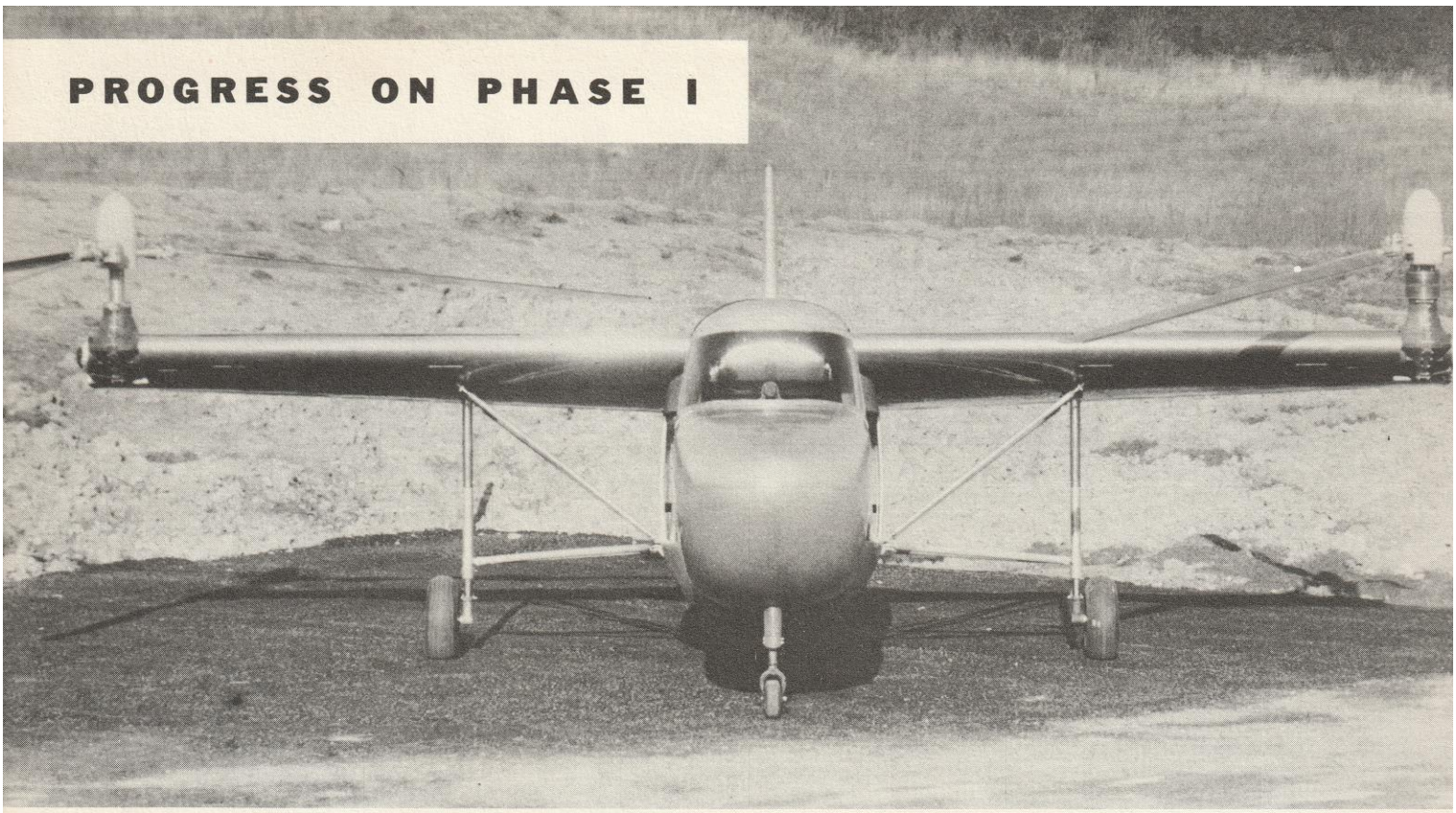




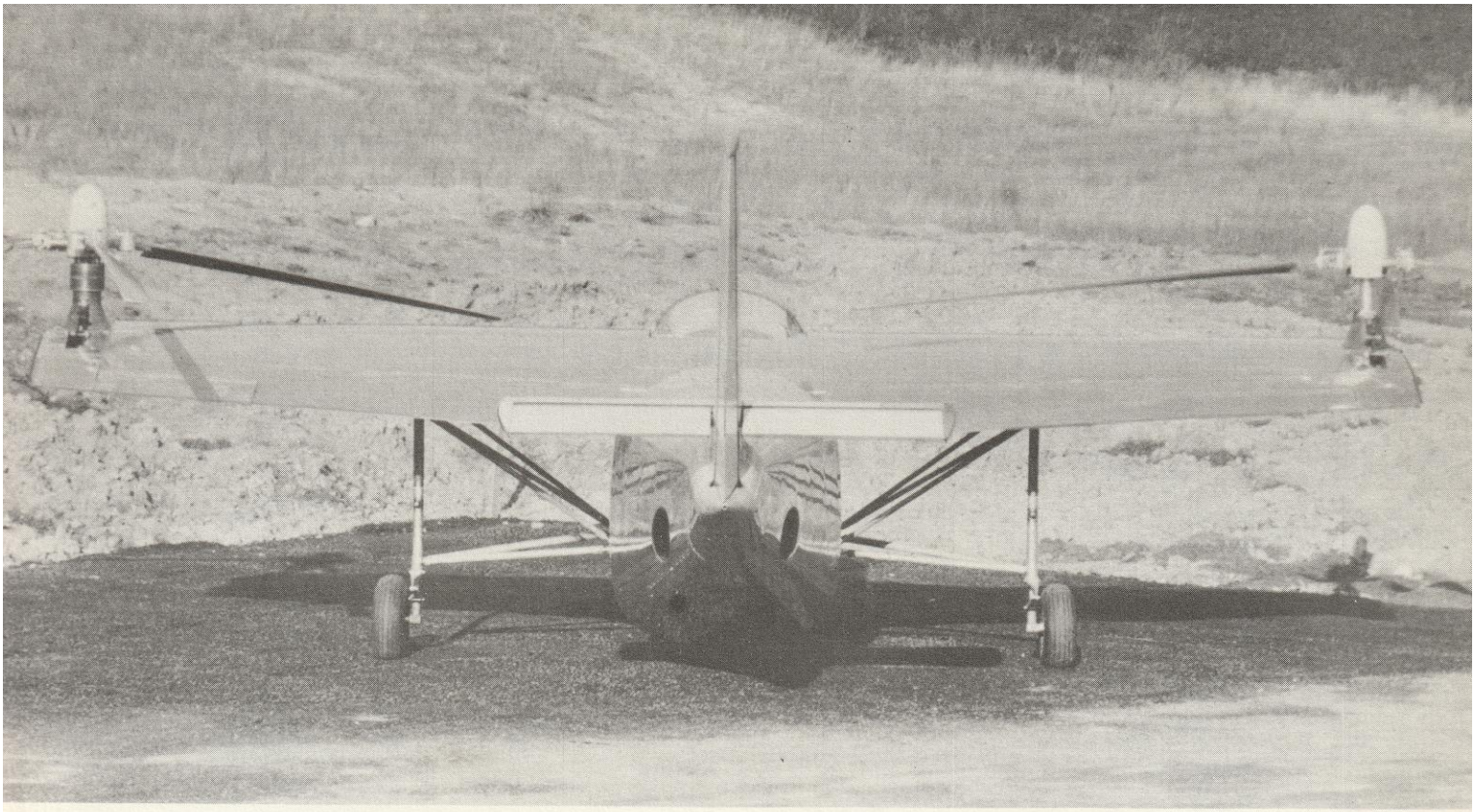
GENERAL SPECIFICATIONS

Aircraft Model	1-G	2
Gross Weight	1750 lbs.	2249 lbs.
Weight Empty	1450 lbs.	1749 lbs.
Useful Load	300 lbs.	500 lbs.
Engine Model	Lycoming O-290-A	Lycoming O-435-23
No. of Engines	1	1
Engine Rating (Normal Rated Power)	160 HP @ 3000 rpm	250 HP @ 3200 rpm @ 700 ft.
Blade Chord (Constant)	0.356 ft.	0.435 ft.
Theoretical Blade Area per Rotor	9.09 sq. ft.	11.76 sq. ft.
Disc. Area per Rotor	227 sq. ft.	256 sq. ft.
Rotor Solidity	0.04	0.047
Disc Loading @ Normal Gross Weight	3.86 PSF	4.4 PSF
Power Loading @ Normal Gross Weight	10.9 lb/bhp	9.0 lb/bhp
Blade Loading	96.5 PSF	95.7 PSF
Wing Loading @ Normal Gross Weight	23 lb/sq. ft.	22.49 lb/sq. ft.

PROGRESS ON PHASE I



Fabrication of the Model 2 airframe was begun on 15 March 1956. Detailed design was completed on 10 September 1956, and the engine was installed on 20 September 1956. However, some of the GFAE engine accessories, which were requested for bailment on 17 April 1956, have not yet been received by the contractor. The contractor has been advised that these items will be shipped in January 1957.



Unforeseen difficulties in obtaining a satisfactory case casting for the new center transmission caused a delay in completing this component. However, this situation has not delayed the project because the old center transmission has been available and would be adequate for pre-flight testing.

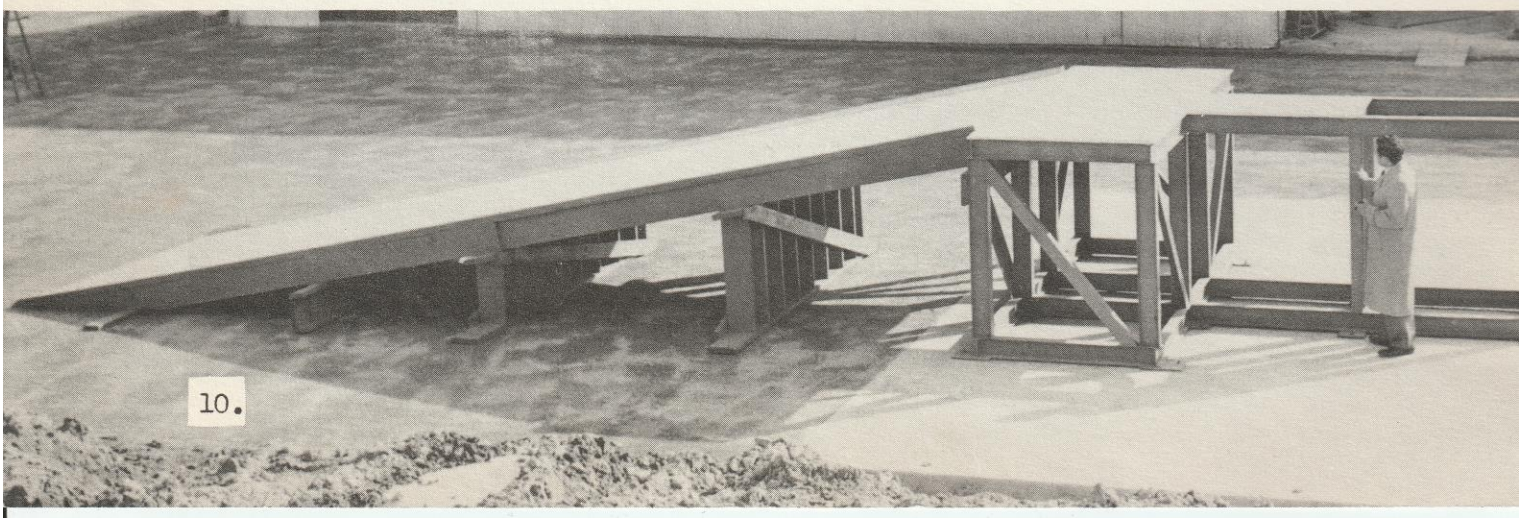
Phase I of Contract No. AF 33(616)-3647 was completed on 31 October 1956.

PROGRESS ON PHASE II

Phase II of this contract requires proof of the mechanical integrity of the aircraft. As a first step in the fulfillment of this requirement, all mechanical components have been subjected to magnaflux or X-ray inspection to assure their integrity.

The mechanical integrity of the completed aircraft will be tested by operating it through the complete rotor speed range in the helicopter and airplane regimes and through conversions from one regime to the other while the aircraft is installed on a tie-down test stand. However, before the tie-down testing is begun, the aircraft will be subjected to shaker tests to determine vibration response of the aircraft structure. In order to eliminate the possibility of encountering induced vibration during tie-down testing, the test stand has been designed and constructed as a stiff structure. Rigidity has been obtained by using heavy welded steel mumbers embedded in a solid concrete base. This test stand was completed on 8 June 1956, but factors beyond the control of the contractor caused a delay in completing the paving of the area surrounding the test stand. In the process of excavating to run an oil pipe line across this contractor's property, the Sun Pipe Line Company damaged the existing sewage and drainage system, making the ground around the test stand unfit for paving. Transcendental has repaired the damaged drainage system, and black top has now been installed around the stand.

TEST STAND



PROGRESS ON PHASE III

The flight test programs to be conducted on the Model 2 Convertiplane as Phase III of Contract No. 33(616)-3647 include stability, control, general performance, and measurement of rotor stress in flight.

A proposed flight test program for stability, control and general performance (TAC Report No. 2R90-3) and the instrumentation methods and requirements for this program (TAC Report No. 2R90-4) were submitted to WADC on 10 May 1956. During the latter part of June, 1956, Transcendental engineers met with the Project Officer at Wright-Patterson Air Force Base to discuss the flight test program which had been submitted. In order to incorporate the additions to the contractor's proposed flight test program as suggested by WADC personnel, revised reports (TAC Report No. 2R90-7 and 2R90-8) were prepared and were submitted to WADC for approval on 18 September 1956. Although the contractor has not, as yet, received formal approval of the proposed test program, informal agreement with the revised program has been indicated by cognizant WADC personnel.

In conjunction with the instrumentation proposal, the contractor prepared and submitted a list of service and ground vibration instruments required. On 1 August 1956, at the request of WADC, a revised list was submitted which included specifications and Federal Stock Code Number of each item to facilitate the supplying of this equipment from government stock or to permit purchase of unstocked items by the government. On 14 August 1956, the contractor submitted a list indicating the description and cost of each flight test instrument required.

On 22 October 1956, WADC informed the contractor that the vibration instrument and a few service instruments were available from USAF stock, but that the remainder of the service and flight test instruments would have to be purchased. At the request of WADC, the contractor prepared a list giving the estimated cost of the instruments not in USAF stock, and submitted same on 11 December 1956.

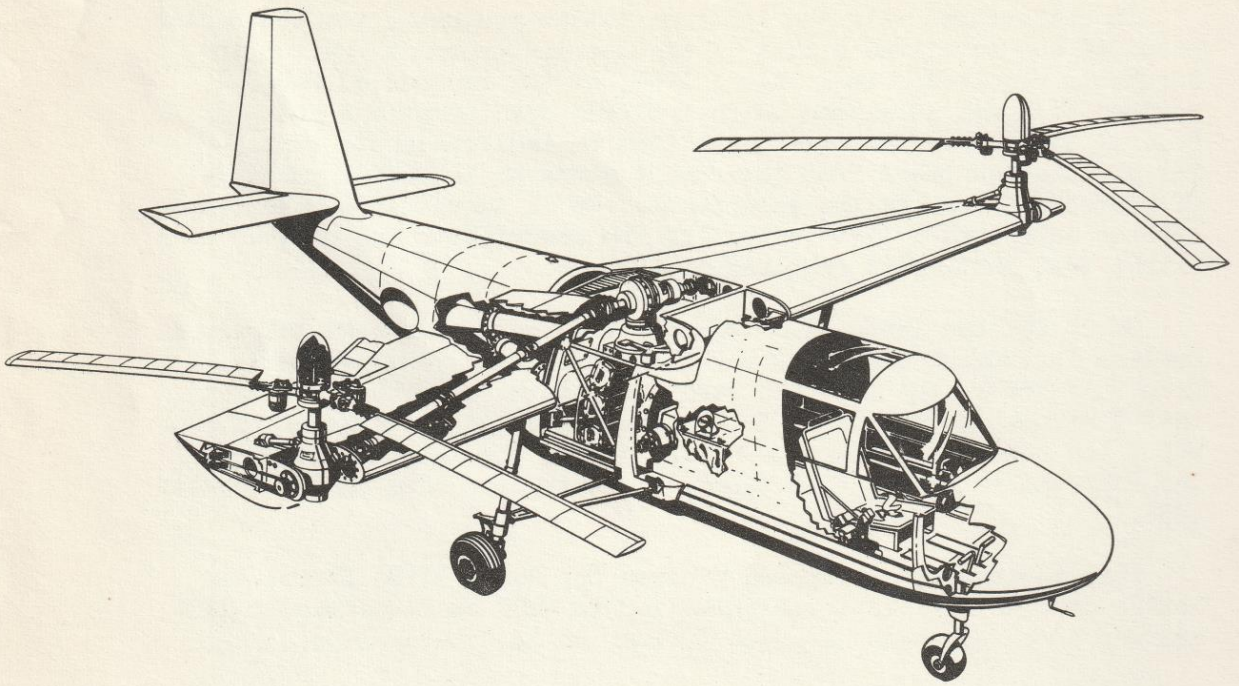
This contractor's proposed program for Rotor Blade Stress and Motion Studies in Flight was submitted to WADC on 24 September 1956, and was approved by the Project Officer on 24 October 1956.

STATUS OF BAILED EQUIPMENT

In accordance with Part VI of Contract AF 33(616)-3647, the government has agreed to bail one (1) Lycoming O-435-23 engine and all instrumentation and data recording equipment required for the performance of the contract. Subsequently the government revised the original bailment agreement by agreeing to bail two (2) Lycoming O-435-23 engines.

The contractor has received both engines, and a Lycoming representative has installed base-type thermocouples on the first engine. However, not all of the engine accessories (which were requested for bailment at the same time as the engines- on 17 April 1956) have been received. Transcendental has been advised that the lacking accessories will be shipped during January, 1957.

Bailment papers for the instrumentation required by this contract were submitted by this contractor on 31 May 1956. As of 31 December 1956, none of this equipment had been received. The contractor has been informed that vibration instrumentation only will be shipped in January, 1957.



Model-2 CONVERTIPLANE

WORK SCHEDULE FOR NEXT QUARTER

During the period covered by this progress report the contractor had anticipated being able to conduct shaker tests on the aircraft for the purpose of determining its frequency response characteristics. When the airframe was completed with the engine installed on 20 September 1956, this phase of testing could have begun except for the fact that the required GFE test equipment had not been received. The three-month delay already incurred in the initiation of this phase of testing is considered to be beyond the control of this contractor, since action required by him to initiate bailment procedure was taken as early as 31 May 1956. Rather than stop progress on the project while awaiting the required GFE instrumentation and equipment required for shaker tests, the contractor has continued fabrication work and has completed the aircraft on the assumption that vibration tests will not dictate any major structural changes.

The contractor plans to initiate vibration shaker tests on the aircraft immediately upon the receipt of the necessary GFE - hopefully in January, 1957. If these tests prove the structure to be satisfactory, the aircraft will be placed on the test stand for tie-down testing. However, if the shaker tests indicate unsatisfactory vibration characteristics, the aircraft structure will require modification prior to initiation of tie-down testing.

It is evident from the foregoing that progress on this contract has been delayed three (3) months because of circumstances beyond the control of the contractor. Furthermore, additional delay may result from the fact that the contractor has been forced to adopt a procedure which is unsound, engineering-wise, in order to keep the project moving forward. It is a well known fact that the vibration problem is the most important of design criteria in this type of convertiplane, and without the proper vibration testing and the accomplishment of indicated modifications, this aircraft could destroy itself on the ground or in the air due to resonant frequency conditions arising from improper aircraft structure. Dispite these considerations, this contractor received an order issued from WADC on 26 October 1956 which stated "Stop work on all items of your contract AF 33(616)-3647 except engine modification portion. Modification portion is to remain within the dollar limits set forth in the contract. Stop order is to remain in effect until Transcendental has completed aircraft in its entirety to the satisfaction of the procuring contracting officer." By letter dated 21 December 1956, the contractor was notified that the stop order of 26 October 1956 had been lifted, subject to specified provisions, effective 14 November 1956.

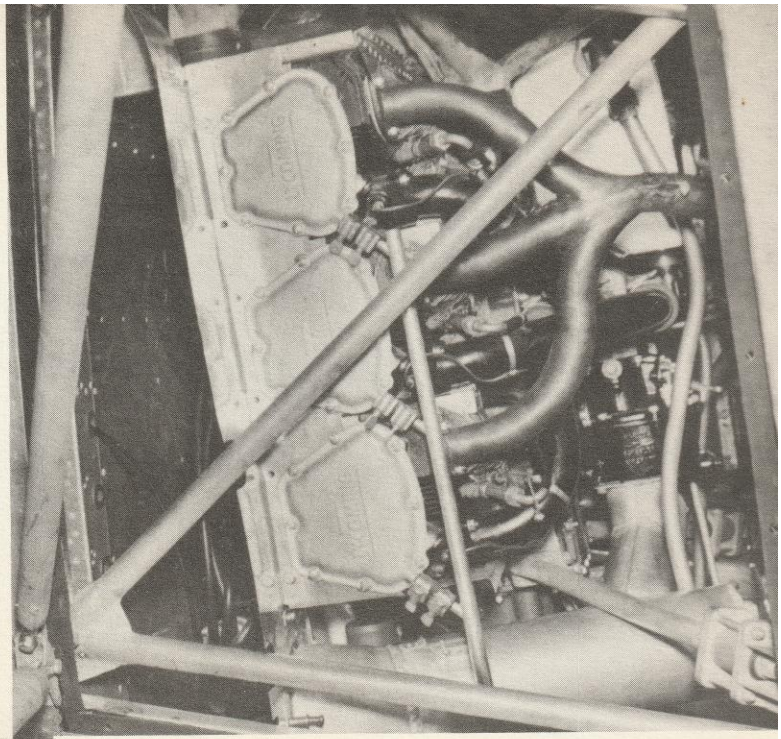
During the next quarter, action should be taken to insure early delivery of the flight instruments which are required for the flight test program but which are not available from Government stock. Attention is invited to the fact that delivery on these instruments from the manufacturer require 90 to 120 days. Any further delay in placing orders will result in delay to initiation of the flight test program.

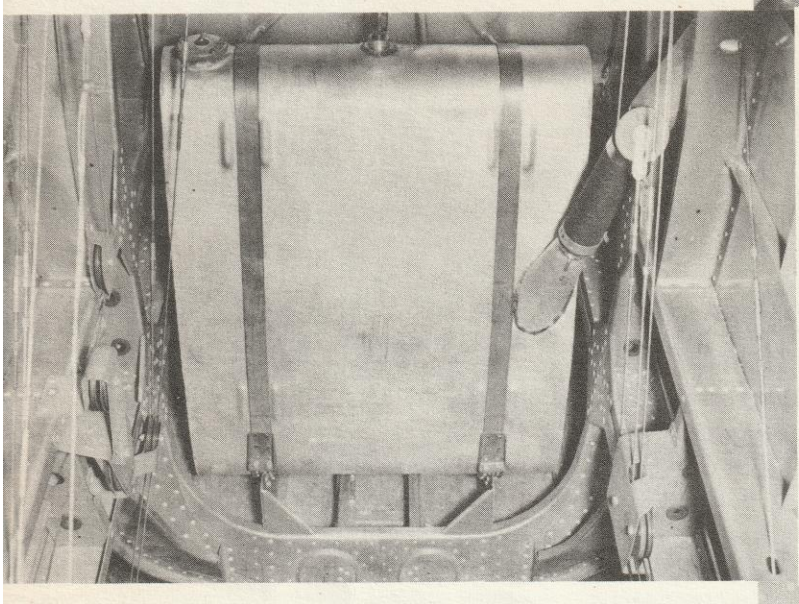
CONTRACT FUNDS EXPENDED TO 31 DECEMBER 1956

All Phases.....	$138,521.47
Amortization.....	11,700.00
Total Reimbursed Costs	$150,221.47

Voucher Costs Unreimbursed to date... $ 23,130.43

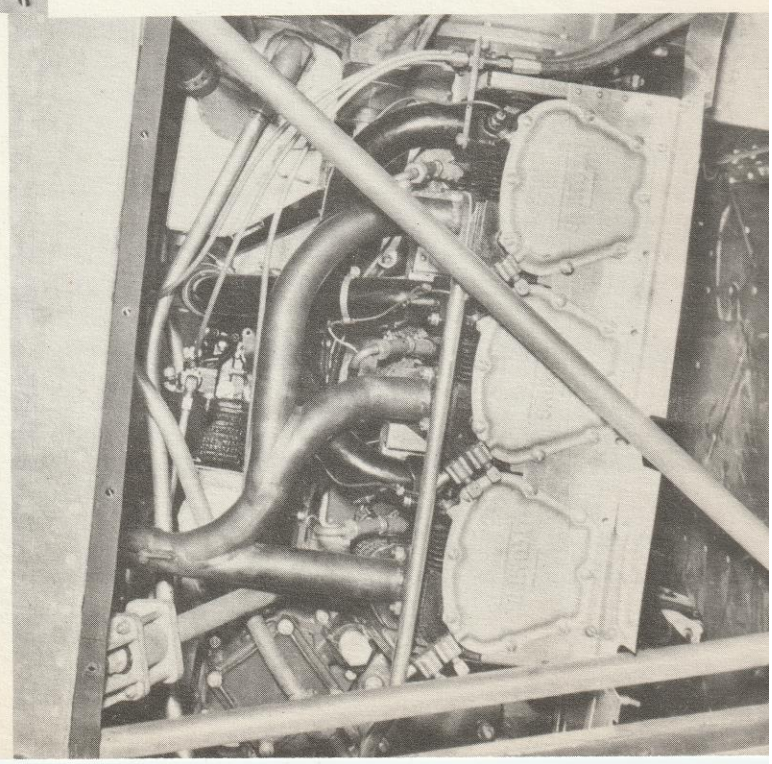
ENGINE INSTALLATION (LEFT SIDE)



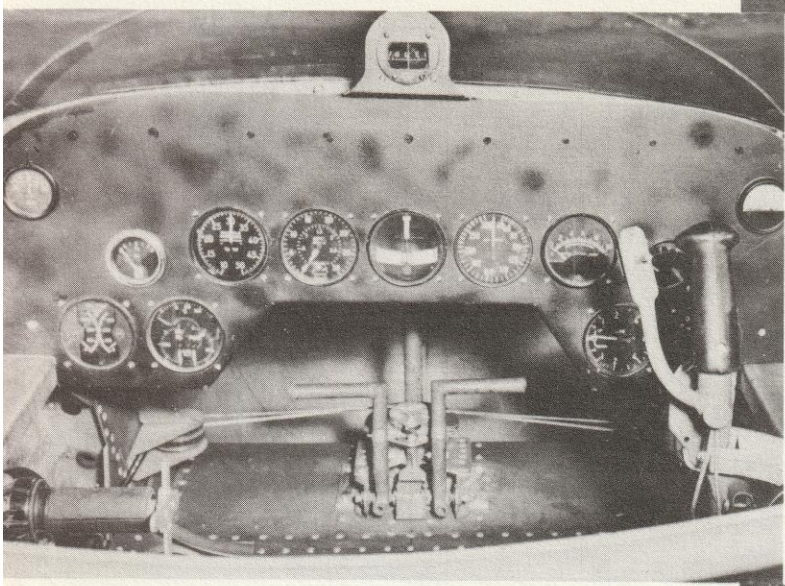


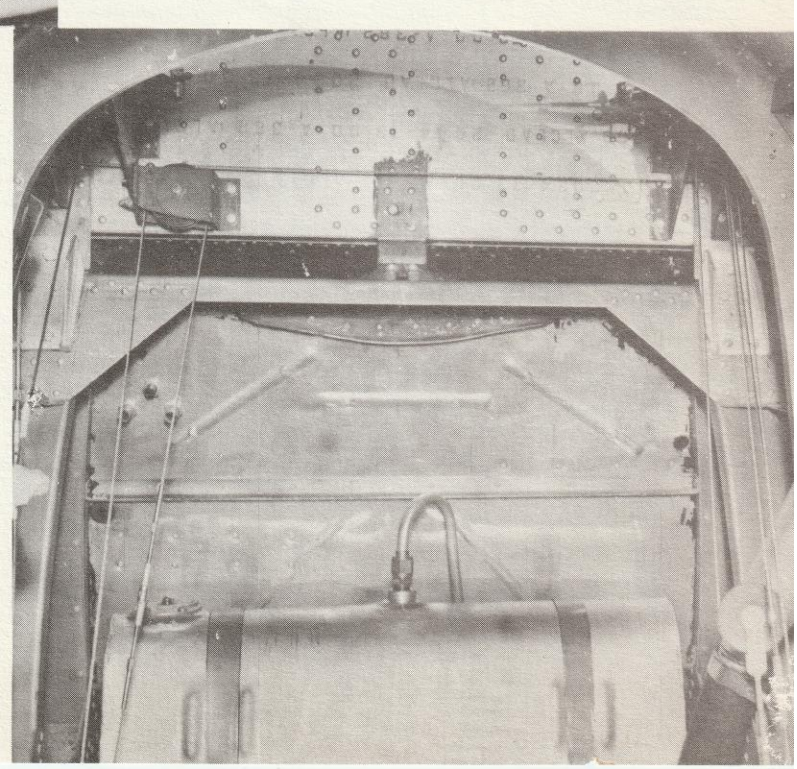
FUEL TANK INSTALLATION

ENGINE INSTALLATION (RIGHT SIDE)



ROTOR TRANSMISSION AND HUB



COCKPIT

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